Independent Simulations of WFIRST Exoplanet Microlensing with MaBμLS

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WFIRST SDT Meeting, 17th May 2012

Overview

1. Simulating WFIRST
2. Results
3. Why are they lower than the interim report?

1. The Simulator - MaBμLS

Manchester-Besancon microLensing Simulator

self-consistently:

- Draws microlensing events from stars in the Besancon Galactic model
- Calculates event rates by sampling from density, kinematic and mass distributions
- Generates planetary lensing models
- Simulates photometry with realistic image simulations

1. The Besancon Model

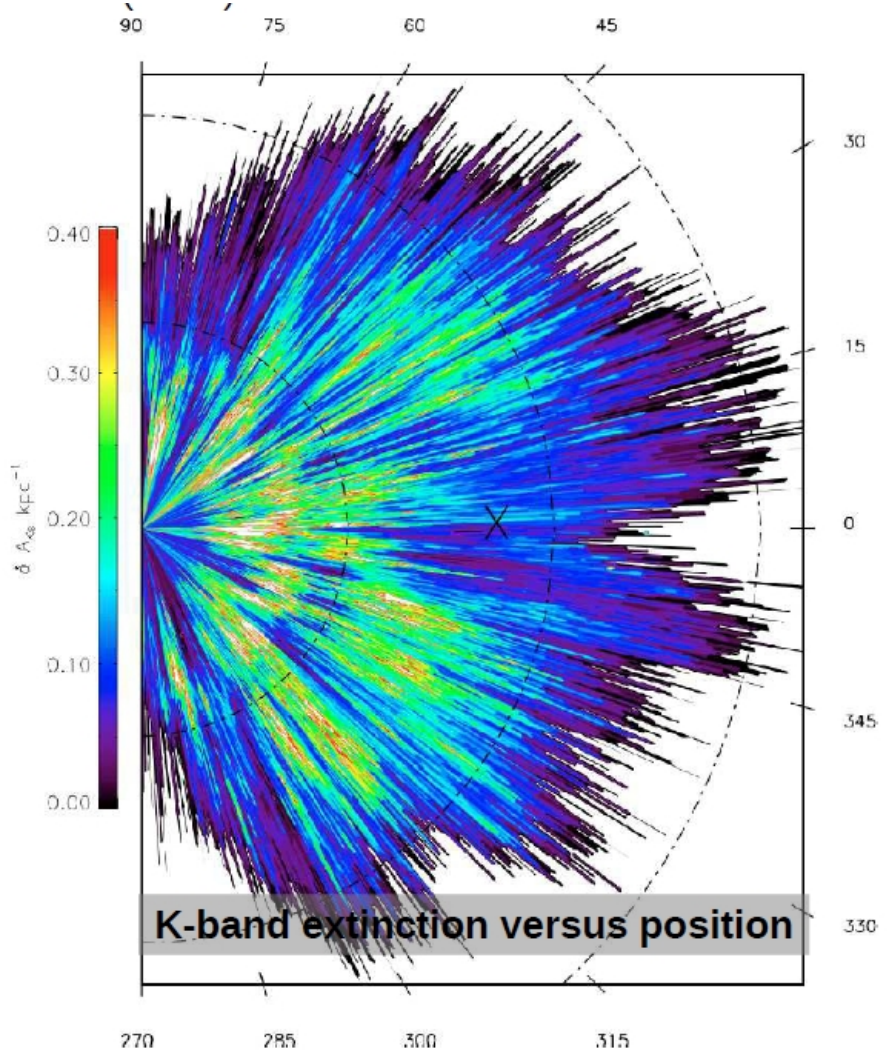
Robin et al 2003, Marshall et al 2006, Robin et al 2012

Galactic population synthesis model:

Incorporates:

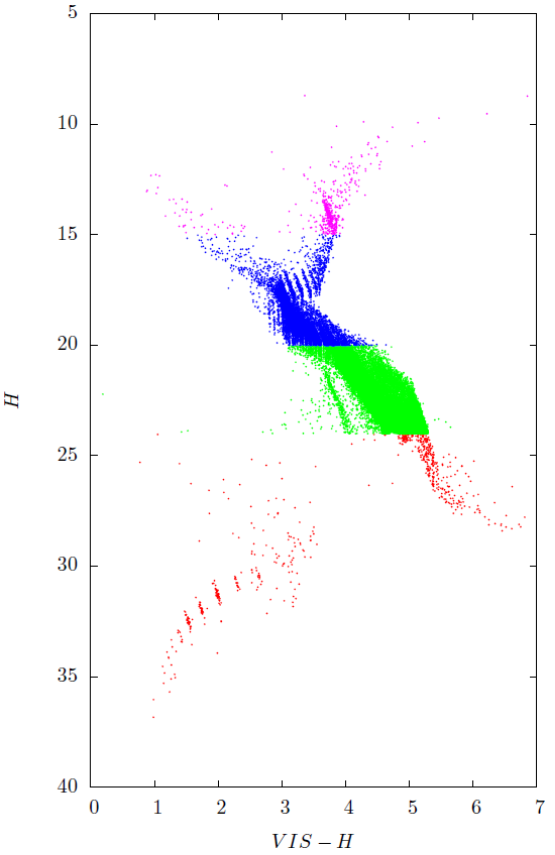
- Bulge+bar, thin+thick discs, stellar halo
- IMF, SFR & Evolutionary tracks
- Stellar atmos models
- 3d dust model

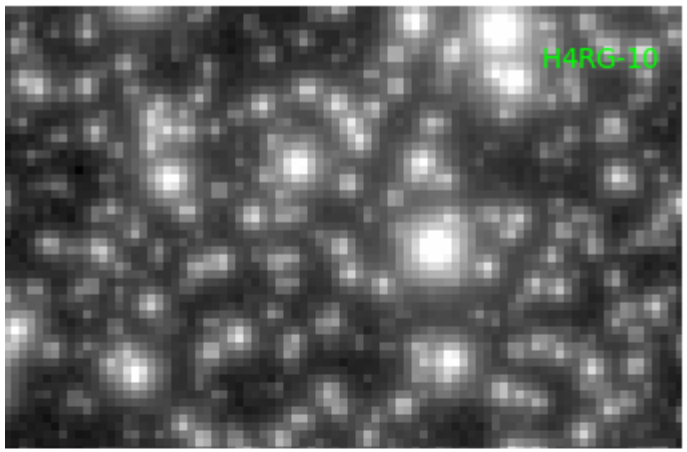
Generates lists of stars and their properties

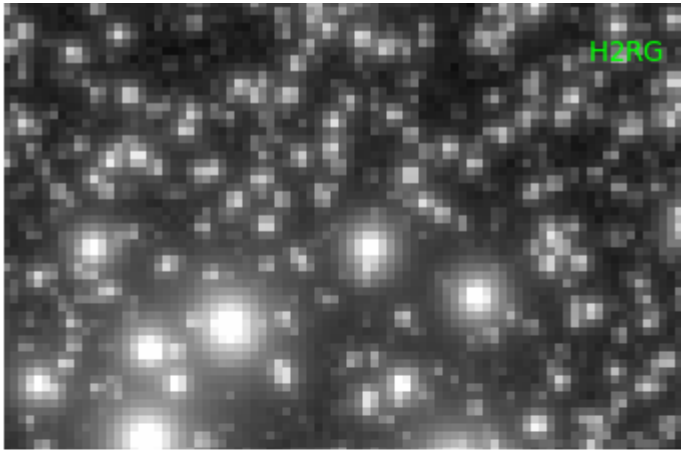


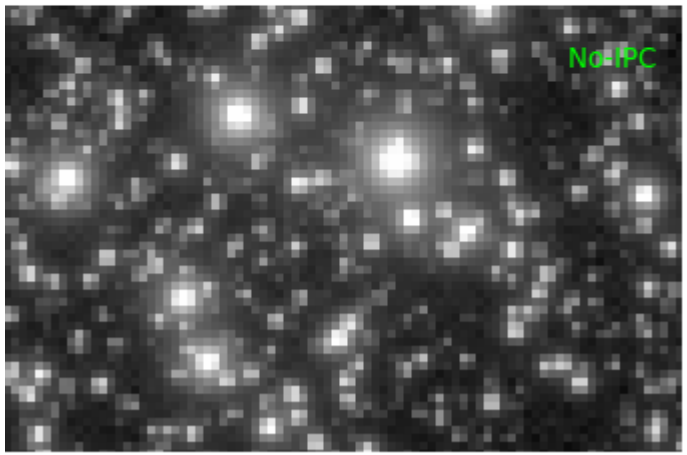
1. Image Simulations

Images are generated from Besancon star catalogues, PSF models and realistic zodiacal light





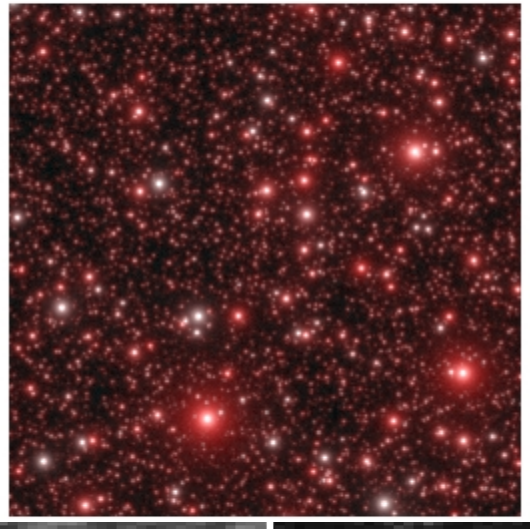


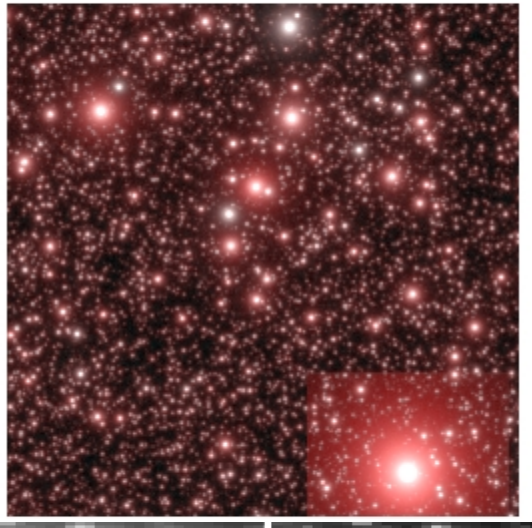


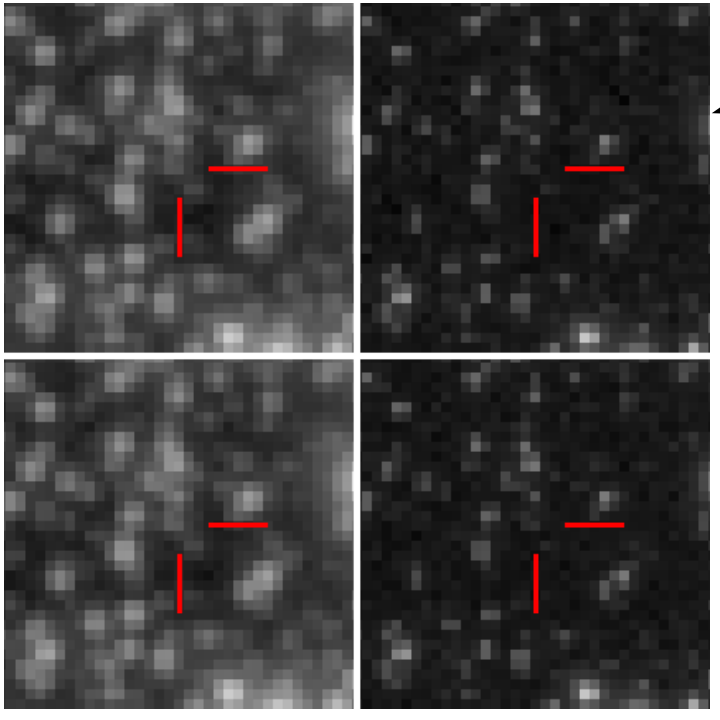
PSF is bandpass convolved Airy function + intra-pixel capacitance

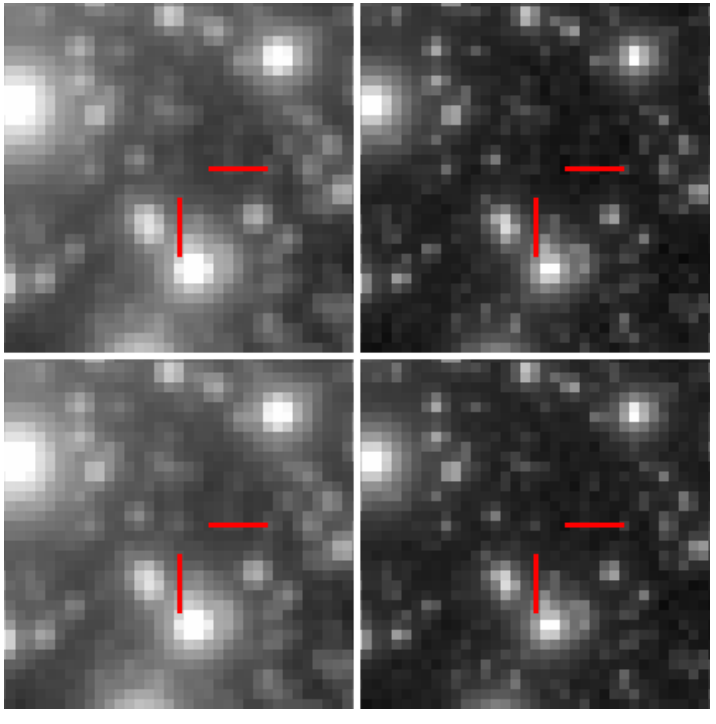
1. Image simulations

Lensing events are added to images







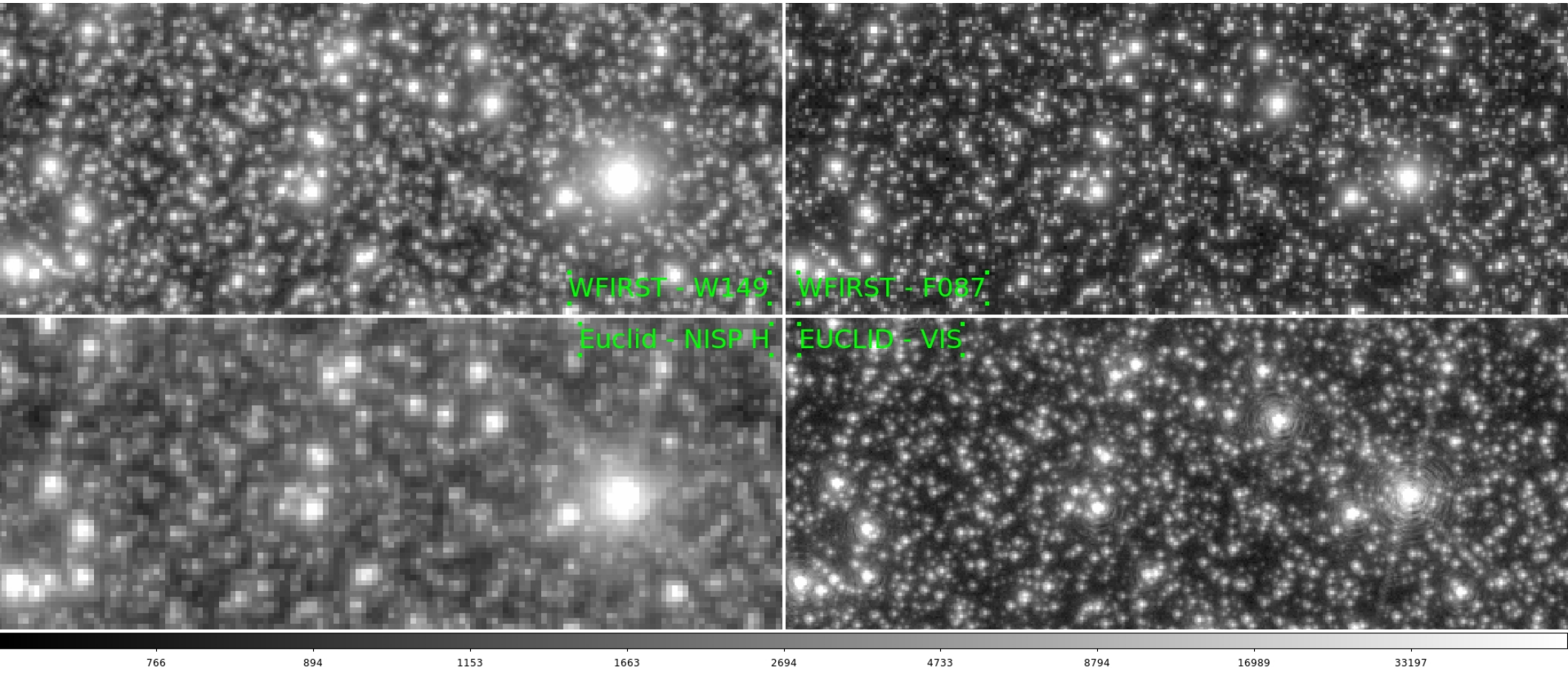


Large PSF kernel for realistic blending (mostly!)

F087 W149

Reddening and PSF size make a difference

1. Why image simulation is important



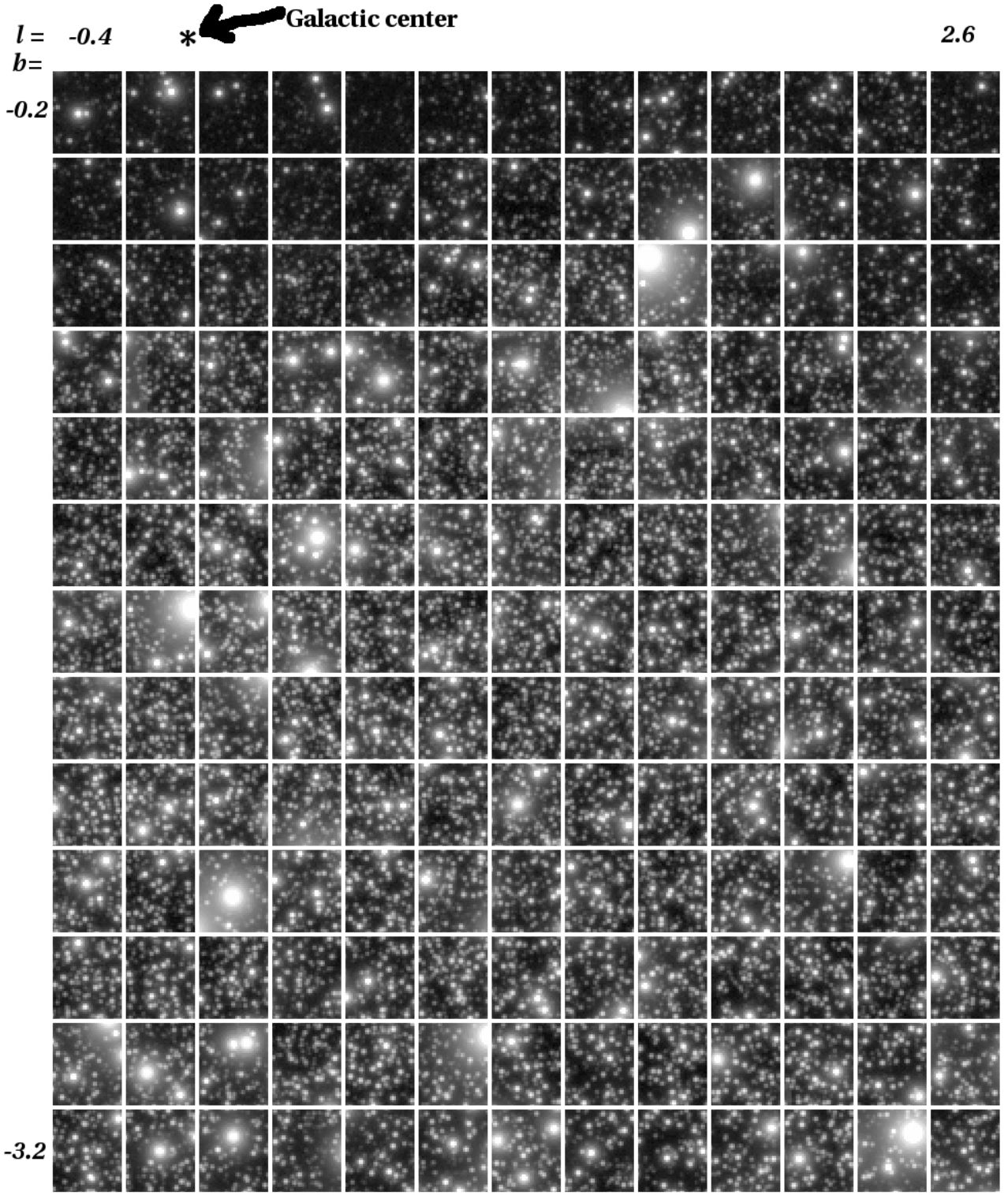
1. What was simulated

- 7x72 day seasons
- 7 fields
- 15 min cadence - 85s exposure W149/W169, 12 hr cadence – 290s exposure F087
- 0.18” pixels
- IDRM – 7x4 H2RG, W149 1-2μm, low Inter-pixel capacitance
- DRM1 – 9x4 H2RG, W169 1-2.4μm, low IPC
- DRM2 – 6x2 H4RG-10, W169 1-2.4μm, high IPC

Besancon model fields

l = -0.4 → 2.6
b = -3.2 → -0.2

13x13 fields of 0.15'x0.15'

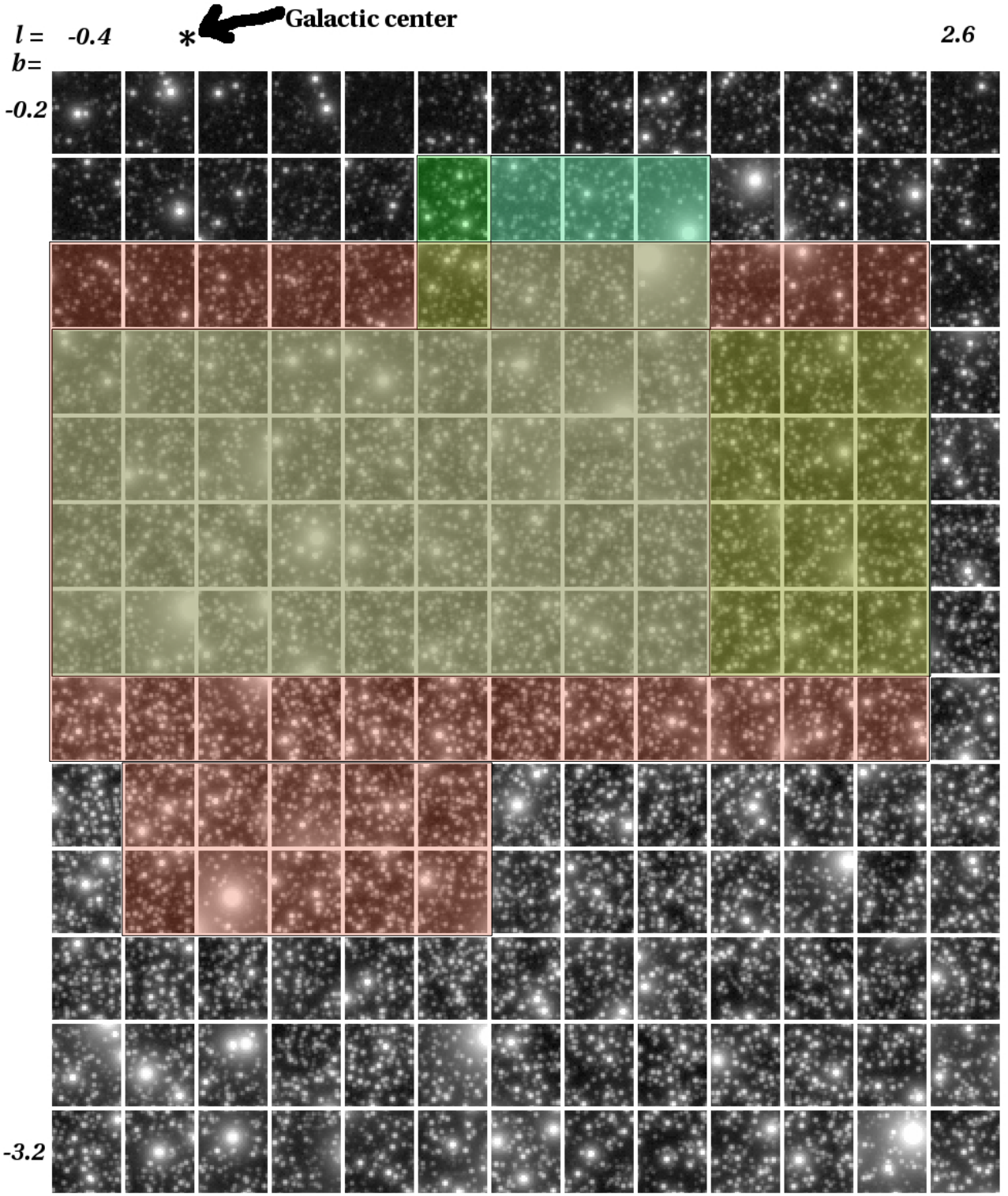


Field selection maximizes the *standard* microlensing event rate

IDRM

DRM1

DRM2



2. Results

Figure of Merit

Design	M=1Mearth T=2yr	θ_E measured	HZ	Free floating	FoM
IDRM	4.88 ± 0.18	~4.2	0.26 ± 0.03	3.85 ± 0.07	~3.1
DRM1	5.86 ± 0.20	~5.1	0.35 ± 0.03	4.79 ± 0.09	~4.3
DRM2	6.42 ± 0.22	~5.8	0.52 ± 0.05	5.81 ± 0.09	~5.9
		θ_E Measured to <20% as proxy for mass measurement		Also requires 3 consecutive 3σ deviations from baseline	
Euclid	Not simulated, but a factor of ~3-4 lower				

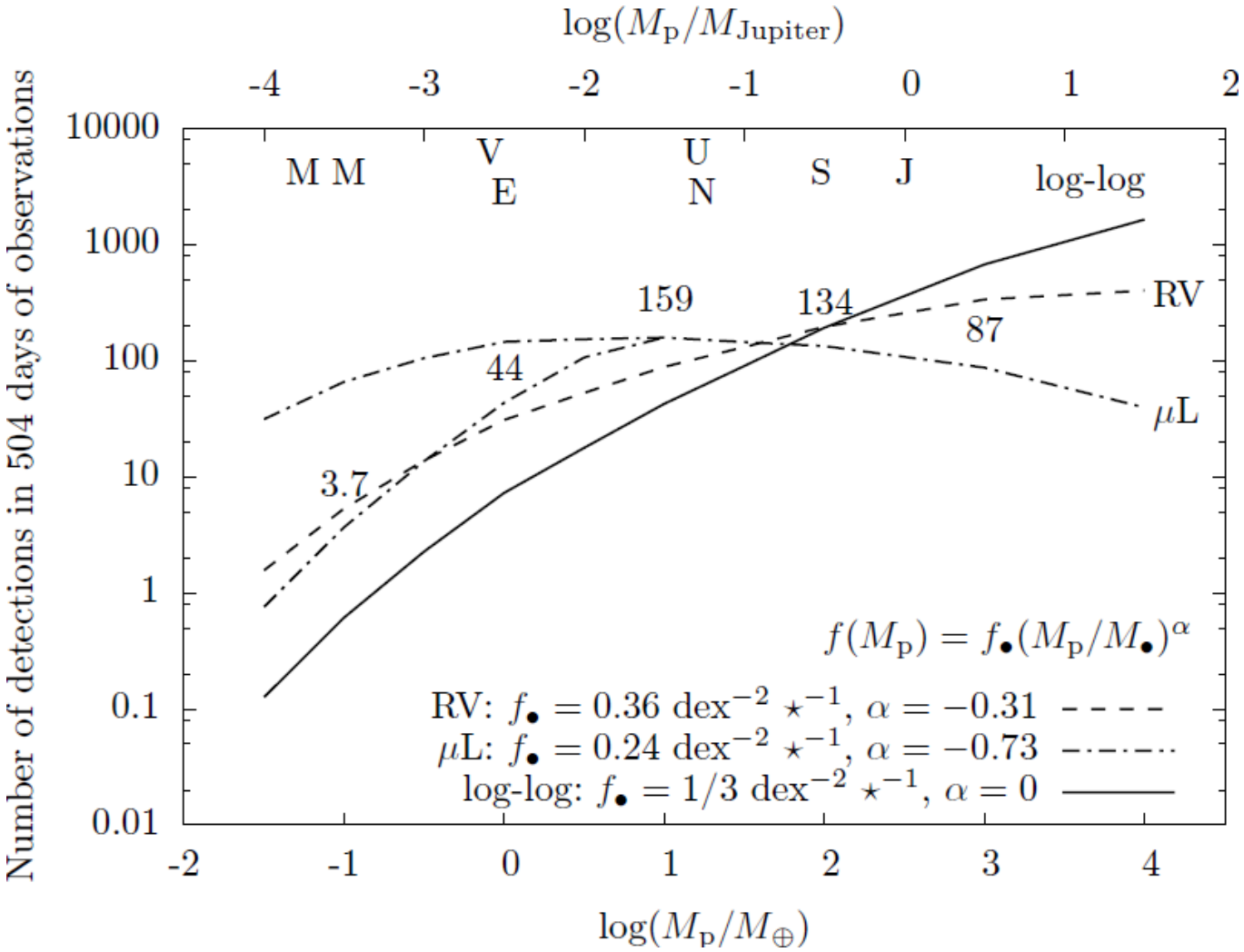
A factor of ~25 lower than simulations for the Interim Report
Why? See section 3

2. What does that get us?

Can look at yields assuming different planetary mass functions:

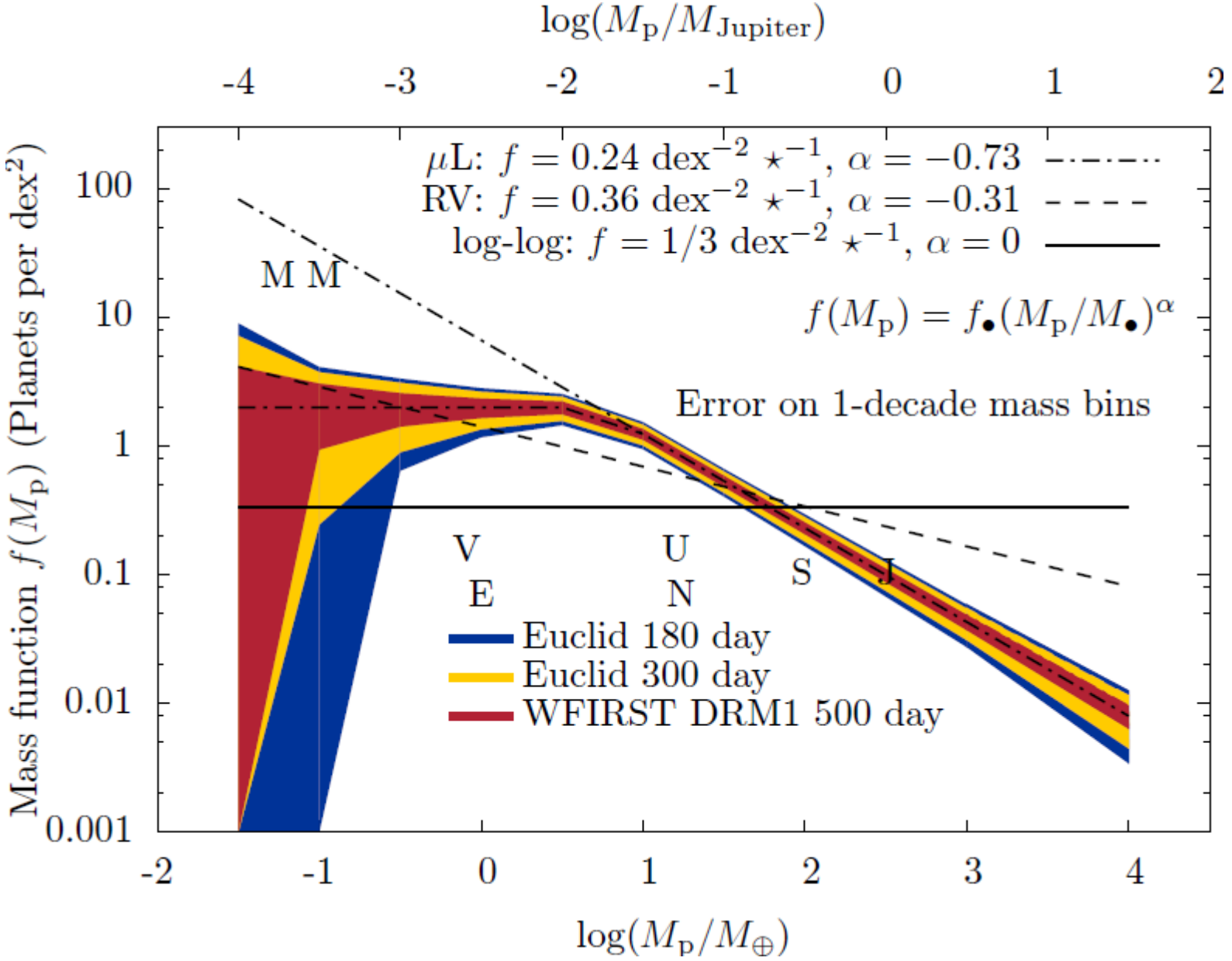
RV: Cumming et al 2010
Slope -0.3
T<2000d

μL: Cassan et al 2012
Slope -0.7 a~3AU



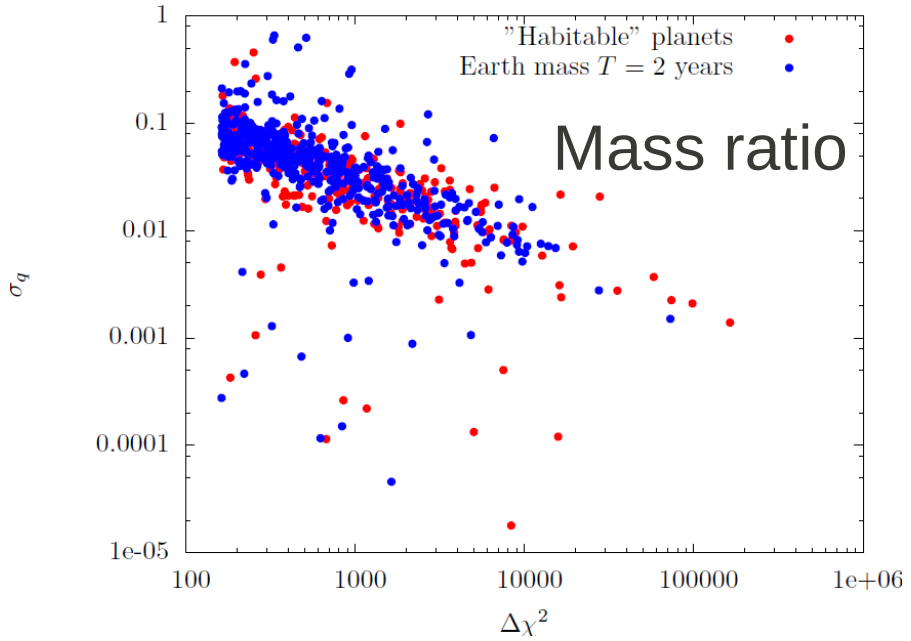
Cassan et al mass function implies close packing of orbits if extrapolated below Mp=5MEarth – Numbers on above plot assume it does not increase below this point

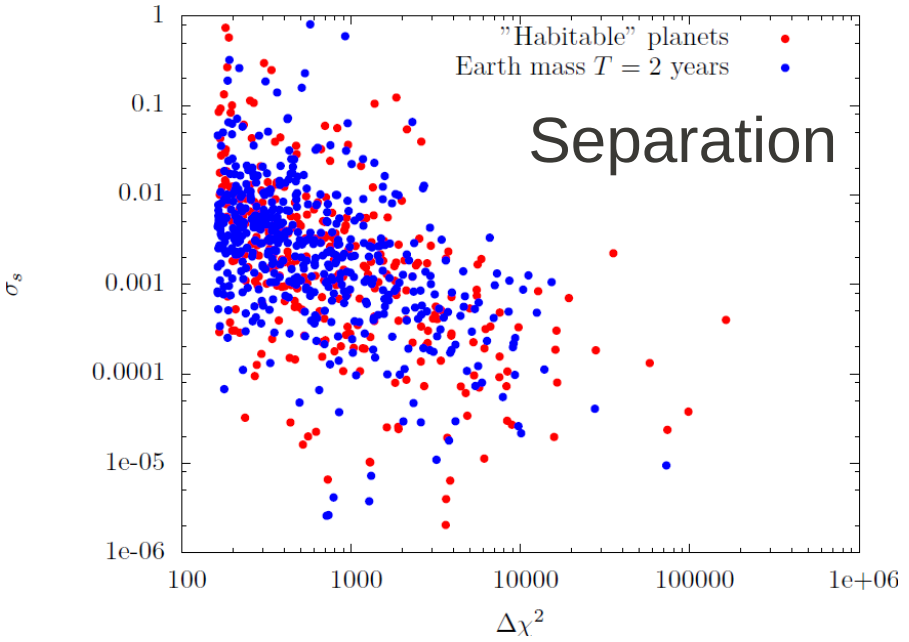
2. Measuring the mass function

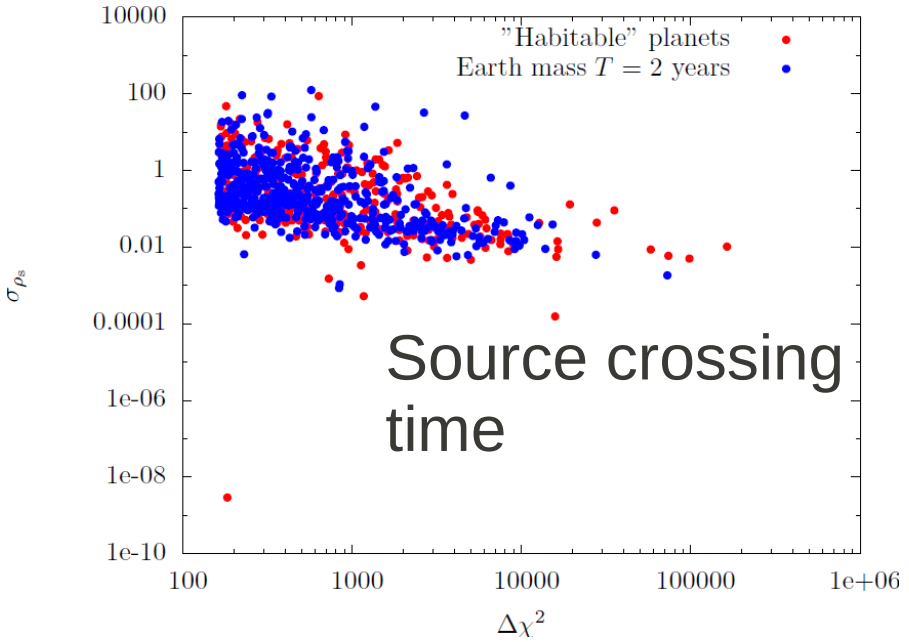


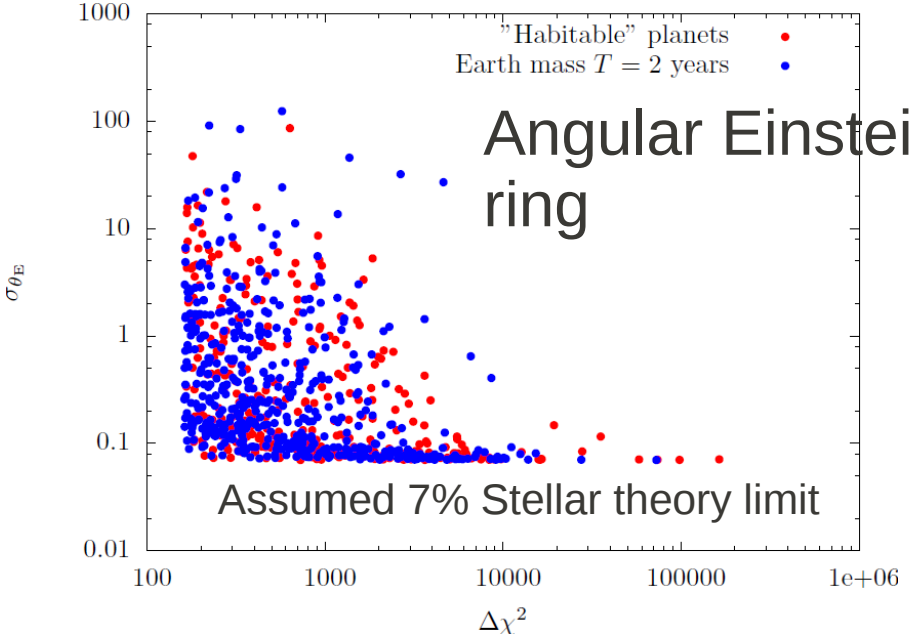
Assumes only half of detected planets have measured masses

2. Measuring planetary parameters

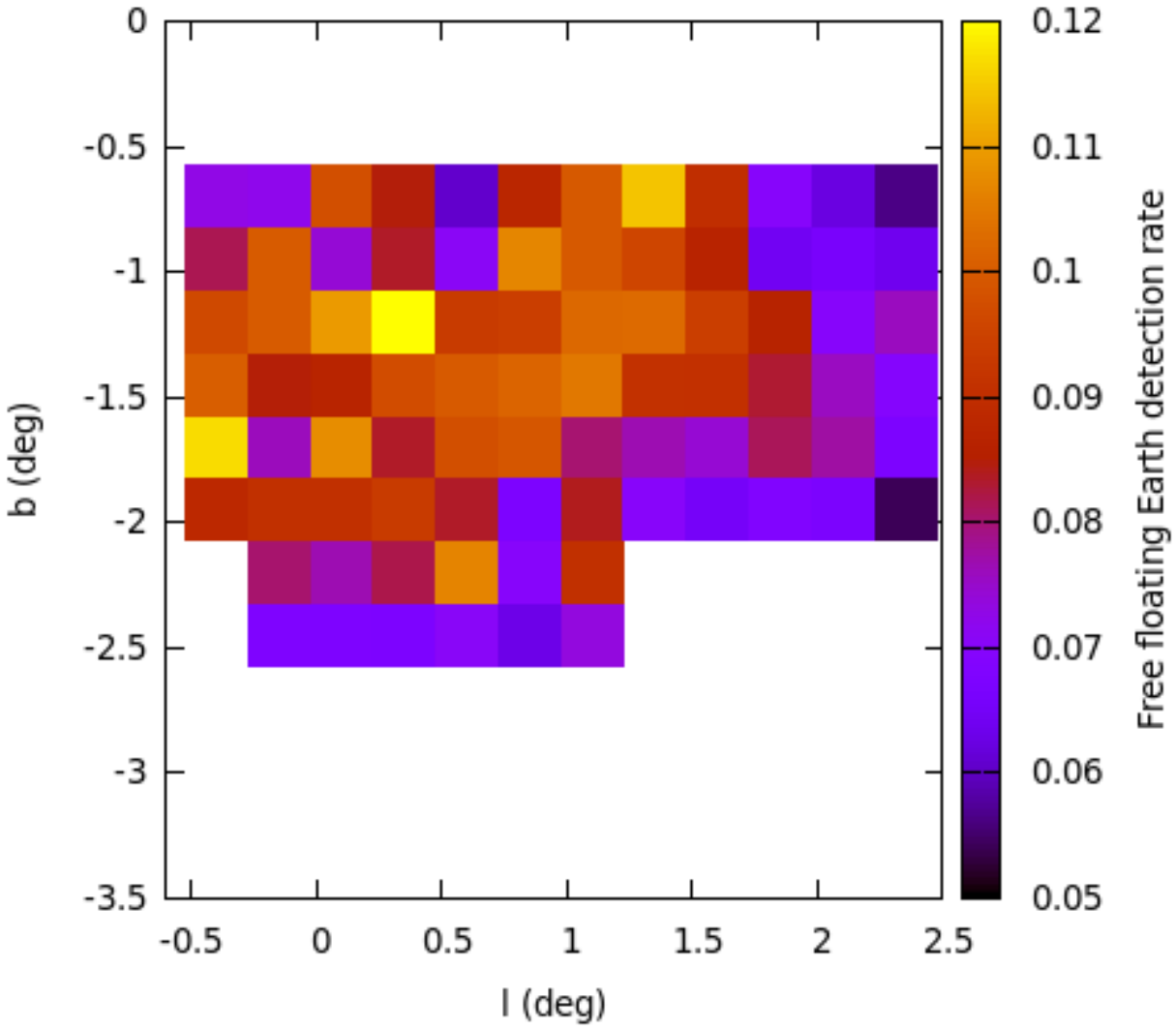








2. Optimization for planet rate



OK. So where did all the planets go?

OK. So where did all the planets go?

Answer: We're not sure yet

3. Why?

Different simulations

- Different photometry simulations
- Different Galactic models

  =Different event rates

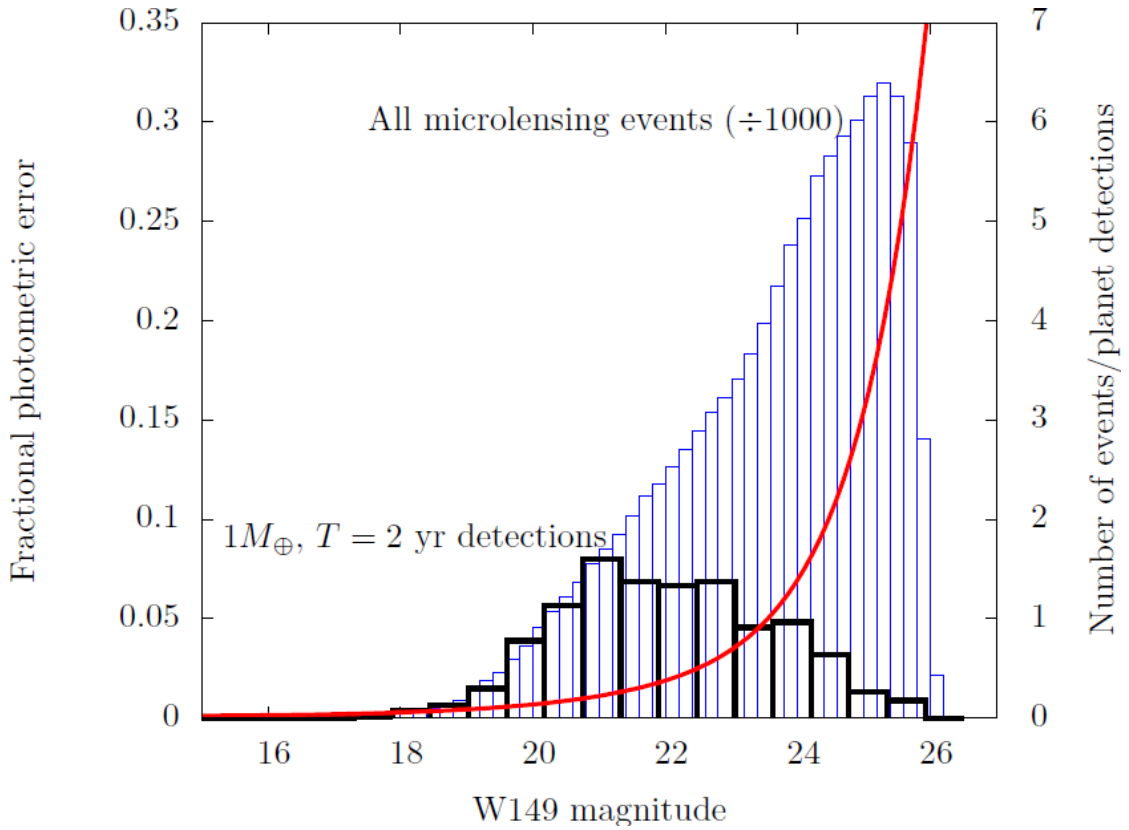
  =Different blending

  etc.

But we should be in the same ball park

3. Is there something wrong with MaBμL?

Bennett & Rhie (1996) say “If we require a minimum deviation of 4% from the standard point-lens microlensing lightcurve, then we find that more than 2% of all M_{Earth} planets ... in the lensing zone can be detected.”

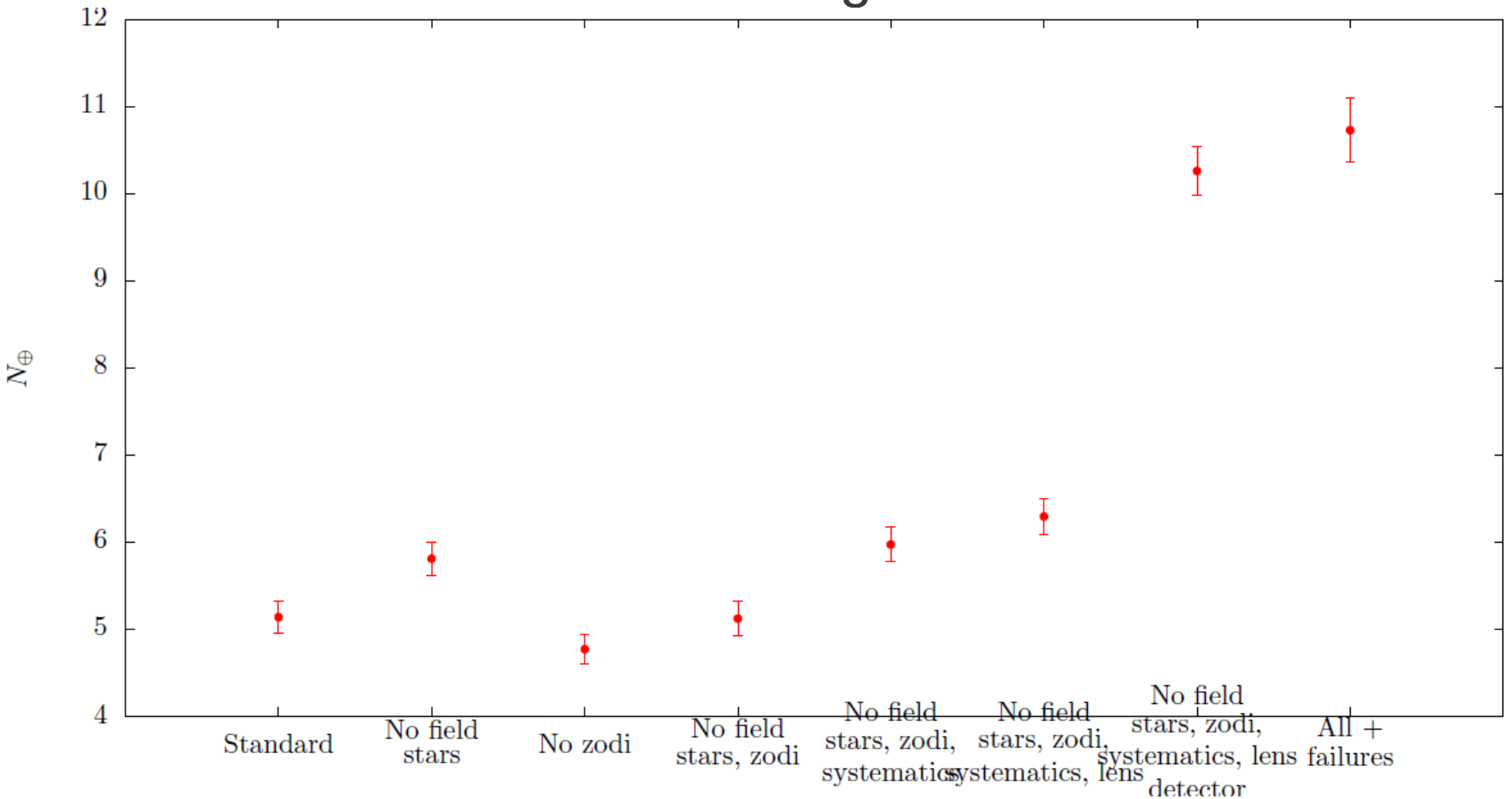


For bright enough sources MaBμLS finds 3-4% LZ detection efficiency

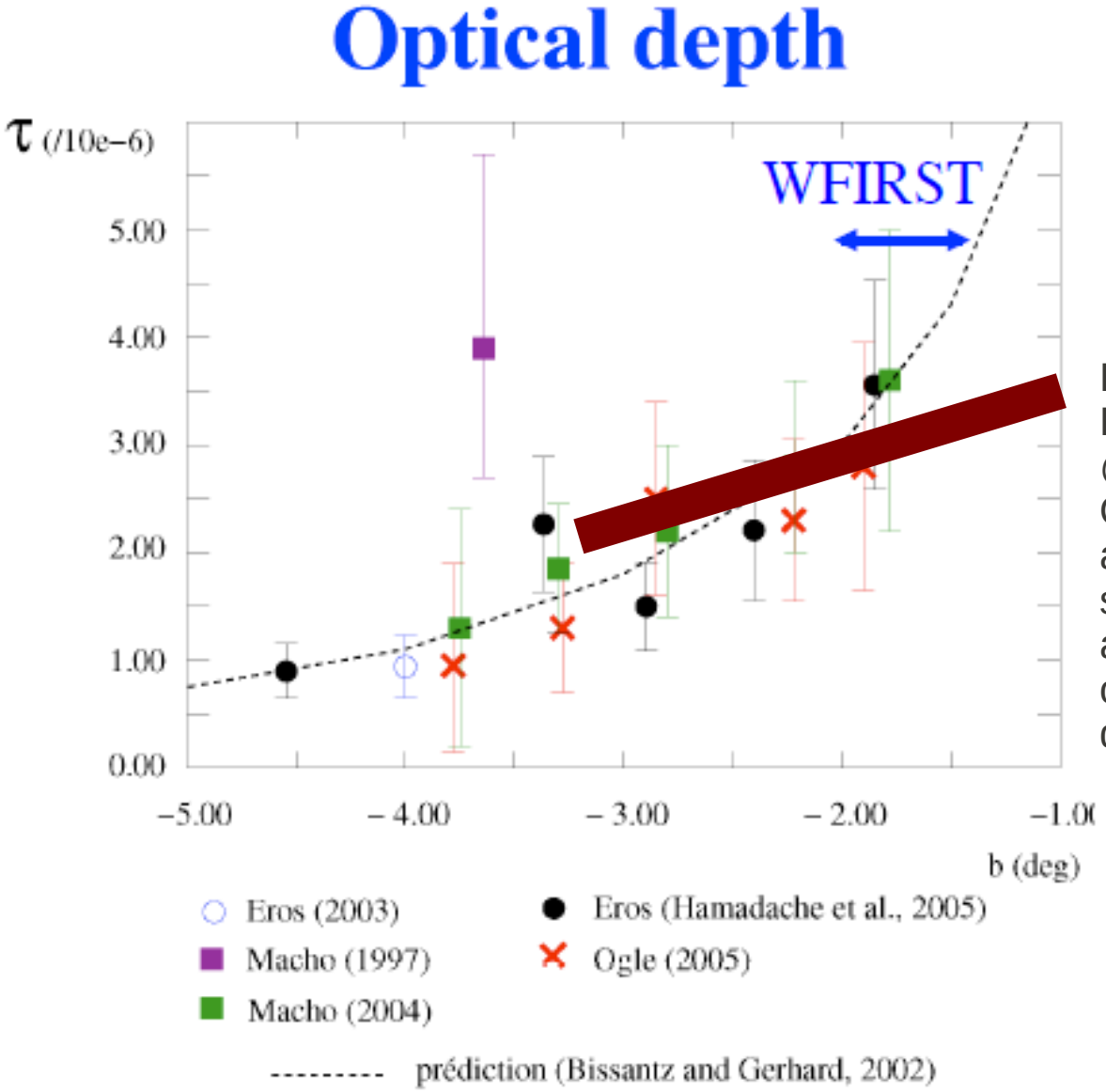
3. Is there something wrong with MaBμL?

Are we being too conservative with our photometry, backgrounds, systematics, blending, rejecting bad events, etc?

Lets remove things and see...



3. That leaves the Galactic model



Besancon Prediction @ 10kpc – Overestimates source averaged optical depth

Besancon optical depths, event rates and source counts lower by up to a factor of 2 than Han & Gould (1995) + other predictions.

Besancon roughly consistent with data, but so are other models

Does not explain entire difference

3. Conclusions

- MaBμLS simulations the most detailed microlensing sims carried out to date
- We still don't know where the discrepancy lies
- Galactic structure is important – could still be uncertain by a factor of a few
- Need more data – VVV may solve
- WFIRST exoplanet microlensing still measures the planetary mass function down to Mars mass